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HOSPITAL TECHNICAL MEMORANDUM

ANTI-STATIC PRECAUTIONS: RUBBER, PLASTICS AND FABRICS

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Hospital Technical Memorandum Number 1

Anti-static Precautions: Rubber, Plastics and Fabrics

CONTENTS

		Paragraph
I	Scope	1
II	Introduction	2
III	Electro-static materials	6
IV	Anti-static precautions in anaesthetising areas	8
V	Plastics and fabrics, incorporating synthetic fibres for use in wards and parts of hospitals (other than anaesthetising areas)	43
VI	Oxygen tents	54
	Appendix	

I. Scope

1. This Memorandum gives guidance on anti-static precautions in hospitals. The Appendix gives recommended limits of electrical resistance for anti-static items and test methods for the measurement of anti-static properties. Anti-static precautions for flooring in anaesthetising areas are not included, as these are dealt with in Hospital Technical Memorandum No. 2.

II. Introduction

2. Static electricification is associated with materials having very high electrical resistance. In electrical conductors, electrons can move freely and any induced potentials will rapidly equalise; whereas in insulators the molecular structure offers considerable resistance to the movement of electrons. Materials having very high electrical resistance therefore, can be charged to very high potentials and should materials at a lower potential be brought close to them, an equalising spark may occur.

3. Highly charged objects can be discharged by persons touching them and when this occurs the persons concerned may experience an electric shock, e.g. during bed making, and although harmless it can be troublesome.

4. Highly charged materials will also attract dust particles from the surrounding atmosphere and this feature can contribute to cross-infection in hospitals.

5. It will be seen therefore that anti-static precautions are not only necessary in anaesthetising areas where electro-static sparking can be dangerous in the presence of flammable gases and vapours, but in other parts of hospitals also, it is desirable to eliminate the use of highly electro-static materials which can cause the nuisance of personal electrification and contribute to cross-infection.

III. Electro-static materials

6. Avoidance of the use of highly electro-static materials is the most effective method of ensuring freedom from the dangers and the nuisance associated with static electrification. Metals and other materials which are electrically conductive are inherently anti-static. Some other materials such as cotton and paper readily absorb moisture from the atmosphere and in this way become anti-static for practical purposes. On the other hand most plastics and some man-made fibres will not readily absorb moisture and in fact tend to be moisture repellent and such materials are electro-static regardless of the humidity conditions.

7. Examples of electro-static materials are: ordinary rubber, wool, silk, polyester, nylon and plastics such as polythene, P.V.C., polypropylene and cellophane.

IV. Anti-static precautions in anaesthetising areas

General

8. The extent of the risk of electro-static sparking in areas where flammable anaesthetics are used was discussed in the "Report of a Working Party on Anaesthetising Explosions" published in 1956. The report recommended that anti-static precautions should be taken in all areas where anaesthetic apparatus employing a closed or partially closed breathing circuit is used with flammable anaesthetics.

Anaesthetic apparatus and associated equipment

9. Satisfactory anti-static anaesthetic equipment and associated components are now generally available and their use will enable anaesthetists to have complete freedom of choice in the selection of anaesthetics.

10. Experience has shown that the risk of electro-static ignition is mainly confined to the areas immediately surrounding the anaesthetic apparatus and its breathing attachments. Flammable gas mixtures escaping from the anaesthetic breathing circuits rapidly dilute to a non-flammable level within a few centimetres of the point of escape and the zone of risk associated with flammable anaesthetics is now recognised as being an area extending for 25 centimetres around any part of the anaesthetic circuit or the gas paths of an anaesthetic apparatus. All portable equipment which is liable to be located within this zone when the anaesthetic apparatus is in use should be anti-static. In addition to eliminating electro-static materials on such equipment, all metallic parts should

be electrically continuous and have an effective anti-static contact with the floor, e.g. by being fitted with anti-static castors or feet.

11. Rubber and similar components should comply with relevant British Standards which include appropriate anti-static precautions. They should have an effective contact with any metal parts to which they are attached. Particular attention should be given to ensuring electrical continuity of metal components used in the breathing circuit to the patient.

Trolleys

12. Trolleys which are liable to be used in anaesthetising areas should comply with a relevant British Standard.

Clear plastic components

13. Functionally, it is very desirable to use certain transparent parts on anaesthetic apparatus and since all known transparent materials which can be economically used are electro-static this requirement conflicts with anti-static precautions.

14. The parts mainly concerned are rotameter visors, expiratory valve bodies, and soda-lime canisters. For mechanical reasons clear plastics are preferred to glass and these materials are highly electro-static. The electro-static risk associated with these clear plastic parts depends on their size and location on the apparatus. The quantity of electro-static charge will be related to the physical size, i.e. the amount of the electro-static material. The possibility of the electro-static material becoming charged, e.g. by being rubbed or brushed against in use will depend largely on its position on the apparatus. Rotameters are usually located where they are unlikely to come into contact with other materials and the electro-static risk associated with the use of clear plastic parts on the rotameter is considered to be negligible.

15. Other items such as soda-lime canisters are liable to be located where they are likely to come into contact with clothing, towelling, etc., and become highly charged.

16. The provision of an electrically conducting mesh on one surface of the plastic, will render the material anti-static for practical purposes. This can be achieved by applying an electrically conducting paint to the inner or outer surface or by the use of a metallic mesh in contact with, or buried in the plastic material. To be completely effective, no point on the plastic surface should be more than 10 mm. ($\frac{3}{8}$ in.) from a conducting area which is electrically continuous with other anti-static components and the discharge contact with the floor.

17. Although the electro-static risk can be eliminated for a period by applying an anti-static polish to exposed surfaces of the plastic, it must be remembered that these polishes (which are usually water-soluble) are liable to get rubbed off in use, and it would be necessary to re-apply the polish following cleaning or sterilising, and at regular intervals during use.

Endotracheal tubes

18. These are moist in use and need not be made of anti-static material; but all other components in the breathing circuit should have satisfactory permanent anti-static properties.

Blood-transfusion tubing

19. The electro-static risk associated with plastic or rubber tubing used with fluids, e.g. with blood-transfusing equipment and heart-lung machines, is not considered significant. Metal supports for blood-transfusion equipment and metal-work associated with heart-lung and similar machines should be electrically continuous and have satisfactory anti-static contact with the floor.

Electric wiring and cables

20. The electro-static risk associated with rubber or plastic insulation of electric wires and cables is considered to be negligible.

Beds

21. When beds are used to transport patients into anaesthetising areas, constructional materials should not be highly electro-static. Where mattress covers and waterproof sheeting which may be electro-static are used on such beds hazard can be avoided by ensuring they remain covered, as is usual, with a cotton sheet.

Blankets

22. Wool blankets are electro-static and should not be used or taken into anaesthetising areas. Cotton or viscose blankets are anti-static for practical purposes.

Quivers for diathermy electrodes

23. The main purpose of a diathermy quiver is to electrically insulate the "active" electrode from possible contact with metallic and anti-static rubber equipment. They should, therefore, be made of ordinary rubber or a similar electrical insulating material and not anti-static rubber. The electro-static risk associated with these items is considered to be negligible.

Clothing

24. The staff in anaesthetising areas should wear anti-static footwear, and a close-fitting outer garment made of an anti-static fabric. Where these conditions are met, stockings and garments made of electro-static materials worn close to the body are not considered to be a source of danger.

25. Footwear having anti-static soles and heels should comply with British Standard 2506. Overshoes should also comply with British Standard 2506 or be of an anti-static fabric or other satisfactory anti-static material and be of a type which completely encloses the normal footwear and is in close contact with the wearer's legs or clothing, e.g. trousers.

Humidity

26. Experience has shown that humidity alone cannot be relied upon as an anti-static precaution. Humidity plant is of course liable to fail and the degree of humidification which is necessary for anti-static purposes may be difficult to achieve during very dry conditions. Also the high relative humidity necessary for anti-static purposes would be excessive for the comfort of the operating suite staff. Any humidification plant installed should be designed to provide the most comfortable working environment for the operating staff, without regard to anti-static considerations.

27. Another point to be noted is that humidity is much less effective as an anti-static measure with most plastics and with some synthetic fabrics which tend to be moisture repellent and resist the formation of a moisture film on their surface. Where anti-static materials and components are used low humidity conditions would not constitute a risk.

Compliance with British Standards

28. Much of the equipment used in anaesthetising areas is covered by British Standards which include appropriate anti-static requirements. Hospital Authorities are advised to specify compliance with these British Standards where they are appropriate, when ordering equipment.

Anti-static rubber and substitute materials

29. Satisfactory anti-static quality equipment is now commercially available for all rubber and plastic items which are required to be anti-static, e.g. anaesthetic components, castor tyres, footwear, mattresses and pads, tubing, hose, waterproof sheeting, aprons, furniture feet, buffers and belting. Anti-static hard rubber and plastic couplers and connectors are available for use in anaesthetic breathing circuits and are less liable to become damaged and deformed in use than metallic connectors and also eliminate the risk of percussion sparks when dropped.

30. It is generally satisfactory to use anti-static rubber equipment (other than quivers, see para. 23) in conjunction with surgical diathermy but, because of its electrical conducting properties, live electrodes should not be allowed to come into contact with it, otherwise sparking may result. Anti-static rubber is also suitable for insulating the patient from the operating table or other metal work, with surgical diathermy, but as the high frequency currents used may cause local heating if there is only a small distance separating the patient from the metal work, material of at least 6 mm. ($\frac{1}{4}$ in.) dry thickness is advised and, for this purpose, an anti-static cellular rubber pad is suitable.

31. Only rubber and plastic sheeting using carbon black as the conducting agent has been found to have lasting and satisfactory anti-static properties to the degree recommended for use in anaesthetising areas. Attempts have been made to manufacture anti-static P.V.C. sheeting using chemical additives. An advantage of this treatment is that it has little effect on the colour of the material. Only limited anti-static properties have, so far, been achieved by this means, however, and extensive trials have shown that the anti-static properties deteriorate in use. Consequently, at the present stage of development these materials are not considered to be suitable for use in anaesthetising areas.

32. Carbon black printed P.V.C. sheeting to B.S.3878 when available is satisfactory subject to the resistivity complying with the recommended limits and provided that no electrically insulating area on either surface exceeds 30 sq. mm. (0.05 sq. in.)

33. Recommendations on resistance limits, marking and testing of anti-static rubber and similar components, are in the Appendix.

Anti-static fabrics

34. Linen, cotton and viscose are anti-static for all practical purposes. Fabrics made of these fibres are recommended for outer garments and for towelling, etc. used in anaesthetising areas. The anti-static properties of these fabrics are, however, largely dependent on their moisture content, and they should not be used when very dry—e.g. immediately after removal from a heated chest. Sufficient moisture will be regained by the fabrics after a few minutes exposure to conditions of normal humidity to render them anti-static.

Blended fabrics

35. Blended fabrics containing electro-static fibres vary in their anti-static properties according to the blend and manufacture (for further details see paragraphs 52-53). Polyester/cotton blended fabrics however become more electro-static with wear, i.e. due to the cotton surface being worn away, and these are not suitable for use as outer garments or for other uses in anaesthetising areas.

Disposable garments, etc.

36. Disposable garments and other equipment made of cellulosic material are generally satisfactory anti-statically, regardless of the incorporation of, for example, nylon thread reinforcement or a P.V.C. membrane, provided that the exposed surfaces are of natural paper. Waterproofing surface treatments may, however, render the material electro-static and unsuitable for use in anaesthetising areas.

Plastics packaging for sterile goods, plastic hollow-ware, and plastic adhesive film.

37. These materials can be very electro-static but under normal conditions of use are considered unlikely to give rise to an appreciable hazard. When flammable anaesthetics are used however, it is recommended that such materials should not be brought within 25 centimetres of any part of the anaesthetic apparatus.

Shelves and trolley tops in anaesthetising areas

38. The choice of materials for shelves and trolley tops has presented some difficulty because there are at present no materials having all the desired properties.

39. Metal shelves including those having surfaces faced with metal have satisfactory anti-static properties but tend to be very noisy in use.

40. Laminated plastic shelves which incorporate a metal foil close to the plastic surface are not electrically conducting but the metal interlay has the effect of equalising any electro-static charges produced on the plastic surface and this material is satisfactorily anti-static for practical purposes. Shelves of this material should be faced on both sides and with thick shelves, the edges also should be faced.

41. Glass shelves have been extensively used in the past. In spite of the fact that glass is electro-static, objection has not been raised, partly because glass tends to attract moisture and will normally acquire a coating of moisture and so be rendered anti-static in the conditions of atmospheric humidity usually met in anaesthetising areas, and partly because of the objections to alternative materials. Now that more suitable alternatives are available, however, there is less justification for using glass shelves.

Wall finishes

42. Anti-static requirements for wall surfaces are much less stringent that those of say floors, as walls do not normally form part of a discharge path which includes other equipment. Consequently it is sufficient that walls are not significantly electro-static and a surface resistivity not exceeding 50,000 megohms (5×10^{10} ohms) is satisfactory (see Appendix for recommended test method).

V. Plastics and fabrics, incorporating synthetic fibres for use in wards and parts of hospitals (other than anaesthetising areas)

43. Plastic sheeting and fabrics made of synthetic fabrics such as polyester and nylon may be very electro-static in use and cause persons to experience minor electric shocks, e.g. during bed-making. Also materials which are highly electro-static, attract dust and can contribute to cross-infection. Because of these undesirable features it is preferable to eliminate the use of highly electro-static materials in hospitals.

Use of plastic sheeting with babies

44. In addition to the undesirable features mentioned above, there is also a risk of asphyxiation if thin plastic sheeting is used, e.g. as covers for pillows with babies and small children. When electro-statically charged, such materials tend to be attracted to the body and thus could hinder breathing.

Plastic sheeting

45. P.V.C., polythene and similar sheeting is usually very electro-static. Most plastic sheeting can, however, be treated during manufacture to make it less electro-static and so eliminate the nuisance associated with the use of highly electro-static materials. There is no generally accepted specification for this treatment, and equipment necessary to determine its effectiveness is not generally available at hospitals.

46. Recommendations on resistance limits and testing of plastic sheeting are in the Appendix. Where desired, the Department will carry out tests on samples submitted, and report results.

Plastic coated fabrics

47. Anti-static fabrics, such as linen, cotton and viscose, when coated on one side only with plastics such as P.V.C., are only slightly electro-static and are satisfactory in this respect for general use outside anaesthetising areas.

48. Fabrics which are plastic-coated on both sides are usually electro-static; an exception is polyurethane-coated fabric, which is only slightly so.

49. The recommended resistance limits for plastic-coated fabrics are the same as those recommended for plastic sheeting. Recommendations on limits and testing are in the Appendix.

Glass fibre fabrics

50. Uncoated fabrics, woven of glass fibres, are only slightly electro-static under conditions of normal humidity, and if used for screen curtains, etc. their electro-static properties are unlikely to be troublesome.

Plastic hollow-ware (polypropylene, polythene, etc.)

51. Plastic hollow-ware is normally very electro-static, but there appears to be no objection on this account to its general use outside anaesthetising areas (see paragraph 37).

Blended fabrics

52. Highly electro-static fibres such as polyester and nylon can be blended with anti-static fibres such as cotton, linen or viscose to produce fabrics which are only slightly electro-static. The anti-static (i.e. electrically conducting) properties of blended fabrics depend on the quantity (not percentage) of anti-static fibre and, to some extent, on the evenness with which it is distributed through the weaving. There is, therefore, no proportion of electro-static fibre which can be used as a maximum limit. As a general guide, electro-static fibres can be blended with anti-static fabric to the extent of between 30 to 60 per cent of the whole without greatly affecting the anti-static properties, the lower limit relating to a light-weight cloth, and the upper limit to a

heavy one. (That is, the 70 per cent of conducting fibre in the light-weight cloth will probably be equal in quantity and effectiveness to the 40 per cent embodied in the heavy-weight cloth.)

53. Although polyester/cotton blended fabrics tend to become more electro-static with wear, they are considered satisfactory from an anti-static aspect for use in wards.

VI. Oxygen tents

54. Oxygen alone is not flammable and, while it is possible to ignite fibres contaminated with oil or grease, by an electro-static spark in an oxygen enriched atmosphere, experience indicates that the risk is negligible in relation to oxygen tents unless a flammable gas or vapour is also present. Highly flammable liquids should therefore be kept well away from oxygen tents and, if this is done, it will not be necessary to take anti-static precautions in and around oxygen tents.

55. Although oxygen alone is not flammable, flammable materials burn much more readily in oxygen than in air and extreme fire precaution should be taken in places where an oxygen-enriched atmosphere may exist.

56. The possibility of electro-static ignition in pure oxygen under hyperbaric conditions cannot be ruled out. It is important, therefore, to avoid the use of electro-static materials as far as is possible within hyperbaric chambers and to adopt special measures, e.g. anti-static surface treatment, where the use of potentially electro-static materials is unavoidable.

Appendix

Recommended resistance limits and testing methods for anti-static rubber and plastic sheeting and for fabrics for NEW equipment for use in anaesthetising areas

Recommended electrical resistance limits

1. Anaesthetic tubing forming the main connection between the anaesthetic apparatus and the patient: 25,000 ($2{\cdot}5 \times 10^4$) ohms minimum, maximum 1 megohm (10^6 ohms), per 1·5 m. (5 ft.) length.

Mattresses and pads: 5,000 (5×10^3) ohms minimum, maximum 1 megohm (10^6 ohms).

Footwear: 75,000 ($7{\cdot}5 \times 10^4$) ohms minimum, maximum 10 megohms (1×10^7 ohms).

Castor tyres: No lower limit. Maximum 10,000 ohms (10^4 ohms).

Other anti-static items: No lower limit. Maximum 1 megohm (10^6 ohms).

Recommended electrical resistance limits—equipment IN SERVICE in anaesthetising areas

2. The electrical resistance of some anti-static rubber equipment may increase with use. The recommended upper limit for all equipment in service is 100 megohms (10^8 ohms). Equipment having an electrical resistance exceeding this value should be deemed to have lost its anti-static properties and be withdrawn from service.

Marking

3. Each detachable item of equipment made of anti-static rubber should bear a conspicuous indelible lemon-coloured marking, together with the word "anti-static" where practicable. Anti-static rubber tubing which may be cut into shorter lengths after manufacture should have a continuous indelible lemon-coloured line at least 3 mm. ($\frac{1}{8}$ in.) wide, or some similar marking, throughout its length. In addition to the anti-static marking on the tyre, the wheel centres of castors should have a conspicuous indelible lemon-coloured marking.

4. In addition to the anti-static marking, it is important that rubber tubing on anaesthetic apparatus used for connecting gas cylinders, etc. should have a conspicuous and permanent coloured marking appropriate to the gas for which it is to be used in accordance with the approved colour code (British Standard, 349).

Electrical testing

Anti-static rubber equipment

5. The anti-static properties of new equipment should be verified by testing when it is received from the supplier, and periodical tests (at six monthly intervals) should be made on anti-static equipment in use to ascertain that the anti-static properties remain satisfactory. It is not considered necessary to test each item every six months, but representative items of each type of equipment should be tested. If the tests indicate excessive deterioration of an item of equipment, all similar equipment should be tested as frequently as is considered necessary, having regard to the test results. Where the results indicate very slight or no deterioration, the period between tests may be extended. The test is simple and well within the capabilities of an electrician or electro-medical technician.

Testing instruments

6. The test instrument recommended is an insulation tester, having an open circuit voltage of approximately 500 volts D.C. A typical insulation tester has a voltage characteristic such that the voltage falls as the test resistance falls. Other suitable instruments are battery-operated with electronic voltage boosting. Significant errors may occur if the voltage across the test resistance falls below 40 V.

Test method

7. Most of the test can be made using small test clips as the test electrodes. When testing flat surfaces, clean metal electrodes having a flat surface of approximately 625 sq. mm. (1 sq. in.) should be used.

8. Two areas, of approximately 625 sq. mm. (1 sq. in.) each, should be wetted on each item to be tested, the test areas being chosen so that the result represents the resistance of the longest discharge path through the article. Where difficulty is experienced in wetting the surface of the rubber, a wetting agent (e.g. a detergent) should be added to the water. The test areas will usually be at the extreme opposite ends of, for example, tubing and breathing bags, or on the top and bottom surfaces of mattresses and pads.

9. On thin sheeting the test areas should be on the same surface with approximately 50 mm. (2 in.) dry spacing between them. Both surfaces of thin sheeting should be tested. (Measurements made through the thickness of thin sheeting are unreliable as they can be influenced by small isolated areas of conductivity.)

10. When testing trolley castor tyres, the test should be made between the metal frame of the trolley and the tyre to verify the continuity between the castor and the trolley in addition to measuring the resistance of the castor tyre.

11. A convenient method of testing trolley castor tyres is to stand the tyre on a wetted metal plate which is insulated from the floor by, for example, a piece of rubber sheeting. The test should be made between the metal plate and the metalwork of the trolley.

12. For footwear, one of the electrodes should be placed on a surface which will be in intimate contact with the wearer and the other electrode on a surface that will be in contact with the floor, when the footwear is in use.

Plastics and fabrics incorporating synthetic fibres for general use in hospitals (not anaesthetising areas)

13. An upper limit of 50,000 megohms (5×10^{10} ohms) for the surface resistivity of the material would minimise

static electrification sufficiently to ensure freedom from electro-static troubles in parts of hospitals other than anaesthetising areas. The same test method recommended for thin anti-static rubber sheeting is suitable, but the test sample should be on a surface having excellent electrically insulating properties, e.g. polythene. The test instrument should be capable of measuring resistivities up to 100,000 megohms (10^{11} ohms). Ideally tests should be carried out with fabrics conditioned at a relative humidity of 50 to 55 per cent but in general the resistivity will increase by a factor of about 5 for a 10 per cent decrease in relative humidity.

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